

AMENDMENT UNDER 37 C.F.R. § 1.312
U.S. Application No. 10/705,251
Attorney Docket No. Q78440

AMENDMENTS TO THE CLAIMS

This listing of claims will replace all prior versions and listings of claims in the application:

LISTING OF CLAIMS:

1. (Canceled).

1. (Previously-presented) A method for manufacturing a piezoelectric device, comprising the steps of:

forming a bottom electrode on a substrate by an ion beam assist method, wherein by irradiating ion beams on the bottom electrode, said bottom electrode has a specific crystal orientation;

forming a piezoelectric film on top of said bottom electrode by performing a process in which a sol containing the material of the piezoelectric film is applied as a coating, dried and degreased to form a precursor, and this precursor is then fired; and

forming a top electrode on top of said piezoelectric film;

wherein said precursor is irradiated with an ion beam at least once following said degreasing in said step of forming said piezoelectric film.

AMENDMENT UNDER 37 C.F.R. § 1.312

U.S. Application No. 10/705,251

Attorney Docket No. Q78440

2 ~~2~~ (Original) The method for manufacturing a piezoelectric device according to claim 2,¹ wherein said piezoelectric film is formed by repeating a multiple number of times a process in which a sol is applied as a coating, dried and degreased to form a precursor, and [this precursor] is then fired, and said irradiation with an ion beam is performed in a single process of said processes.

3 ~~2~~ (Original) The method for manufacturing a piezoelectric device according to claim 2 or claim 2, wherein said irradiation with an ion beam is performed after said degreasing and before said firing.

4 ~~2~~ (Previously presented) The method for manufacturing a piezoelectric device according to claim 2, wherein said irradiation with an ion beam is performed during said firing.

6 ~~1~~ (Currently amended) The method for manufacturing a piezoelectric device according to claim 1 or 2 ~~claim 2 or 3~~, wherein said piezoelectric film is formed by PZT, BST or a relaxer material.

7 ~~2~~ (Currently amended) The method for manufacturing a piezoelectric device according to claim 1 or 2 ~~claim 2 or 3~~, wherein said piezoelectric film contains a solid solution of PMN_y-PZT_{1-y} consisting of a relaxer material PMN comprising any of the compounds Pb(M_{1/3}N_{2/3})O₃ (M = Mg, Zn, Co, Ni, Mn; N = Nb, Ta), Pb(M_{1/2}N_{1/2})O₃ (M = Sc, Fe, In, Yb, Ho, Lu; N = Nb,

AMENDMENT UNDER 37 C.F.R. § 1.312
U.S. Application No. 10/705,251
Attorney Docket No. Q78440

Ta), $\text{Pb}(\text{M}_{1/2}\text{N}_{1/2})\text{O}_3$ (M = Mg, Cd, Mn, Co; N = W, Re) or $\text{Pb}(\text{M}_{2/3}\text{N}_{1/3})\text{O}_3$ (M = Mn, Fe; N = W, Re) or mixed phases of these compounds, and $\text{Pb}(\text{Zr}_x\text{Ti}_{1-x})\text{O}_3$ (PZT, $0.0 \leq x \leq 1.0$), and is oriented in any of the orientations of a cubic crystal (100), tetragonal crystal (001), rhombohedral crystal (100) or quasi-cubic crystal (100).

~~5~~ (Previously presented) A method for manufacturing a piezoelectric device, the method comprising:

forming a bottom electrode on a substrate by an ion beam assist method, wherein by irradiating ion beams on the bottom electrode, said bottom electrode has a specific crystal orientation;

forming a piezoelectric film on top of said bottom electrode by an ion beam assist method, wherein by irradiating ion beams on the piezoelectric film, said piezoelectric film has a specific crystal orientation; and

forming a top electrode on top of said piezoelectric film.

~~8~~ (Original) The method for manufacturing a piezoelectric device according to claim ~~5~~ 5 wherein said piezoelectric film is formed on top of said bottom electrode by epitaxial growth.

~~9~~ (Previously presented) The method for manufacturing a piezoelectric device according to claim ~~5~~ 5 wherein said piezoelectric film contains a solid solution of $\text{PMN}_y\text{-PZT}_{1-y}$ consisting of a relaxer material PMN comprising any of the compounds $\text{Pb}(\text{M}_{1/3}\text{N}_{2/3})\text{O}_3$ (M =

AMENDMENT UNDER 37 C.F.R. § 1.312
U.S. Application No. 10/705,251
Attorney Docket No. Q78440

Mg, Zn, Co, Ni, Mn; N = Nb, Ta), $\text{Pb}(\text{M}_{1/2}\text{N}_{1/2})\text{O}_3$ (M = Sc, Fe, In, Yb, Ho, Lu; N = Nb, Ta), $\text{Pb}(\text{M}_{1/2}\text{N}_{1/2})\text{O}_3$ (M = Mg, Cd, Mn, Co; N = W, Re) or $\text{Pb}(\text{M}_{2/3}\text{N}_{1/3})\text{O}_3$ (M = Mn, Fe; N = W, Re) or mixed phases of these compounds, and $\text{Pb}(\text{Zr}_x\text{Ti}_{1-x})\text{O}_3$ (PZT, $0.0 \leq x \leq 1.0$), and is oriented in any of the orientations of a cubic crystal (100), tetragonal crystal (001), rhombohedral crystal (100) or quasi-cubic crystal (100).

10. (Previously presented) The method for manufacturing a piezoelectric device according to claim 5, wherein said bottom electrode is formed by a metal material.

11. (Previously presented) The method for manufacturing a piezoelectric device according to claim 5 wherein said bottom electrode is formed by a conductive oxide material with a perovskite crystal structure.

12. (Previously presented) The method for manufacturing a piezoelectric device according to claim 8, wherein said bottom electrode contains any of the compounds M_2RuO_4 ($M = Ca, Sr, Ba$), RE_2NiO_4 ($RE = La, Ce, Pr, Nd, Pm, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Y$), $REBa_2Cu_3O_x$ ($RE = La, Ce, Pr, Nd, Pm, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Y$), $MRuO_3$ ($M = Ca, Sr, Ba$), $(RE.M)CrO_3$ ($RE = La, Ce, Pr, Nd, Pm, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Y; M = Ca, Sr, Ba$), $(RE.M)MnO_3$ ($RE = La, Ce, Pr, Nd, Pm, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Y; M = Ca, Sr, Ba$), $(RE.M)CoO_3$ ($RE = La, Ce, Pr, Nd, Pm, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Y; M = Ca, Sr, Ba$), or $RENiO_3$ ($RE = La, Ce, Pr, Nd, Pm, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Y; M = Ca, Sr, Ba$), or RE_2NiO_4 ($RE = La, Ce, Pr, Nd, Pm, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Y$).

AMENDMENT UNDER 37 C.F.R. § 1.312

U.S. Application No. 10/705,251

Attorney Docket No. Q78440

25. (Withdrawn) The method for manufacturing a piezoelectric device according to claim 14, wherein the portion of said intermediate film that is formed using said ion beam assist method contains a compound with a fluorite structure such as $RE_x(Zr_{1-y}Ce_y)_{1-x}O_{2-0.5x}$ ($0.0 \leq x \leq 1.0$, $0.0 \leq y \leq 1.0$: $RE = La, Ce, Pr, Nd, Pm, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Y$) or a solid solution of such compounds, or a compound with a pyrochlore structure such as $RE_2(Zr_{1-y}Ce_y)_2O_7$ ($0.0 \leq y \leq 1.0$: $RE = La, Ce, Pr, Nd, Pm, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Y$) or a solid solution of such compounds, and has a cubic crystal (100) orientation.

13 26. (Original) A method for manufacturing a piezoelectric device comprising the steps of:

forming a bottom electrode on a substrate;

forming a piezoelectric film on top of said bottom electrode; and

forming a top electrode on top of said piezoelectric film;

wherein said step of forming a piezoelectric film comprises the steps of forming a first layer by an ion beam assist method, and forming a second layer by continuing deposition with the ion beam assist stopped.

14 27. (Previously presented) A method for manufacturing a piezoelectric device comprising the steps of:

forming a bottom electrode on a substrate;

AMENDMENT UNDER 37 C.F.R. § 1.312
U.S. Application No. 10/705,251
Attorney Docket No. Q78440

forming a piezoelectric film on top of said bottom electrode by an ion beam assist method, wherein by irradiating ion beams on the piezoelectric film, said piezoelectric film has a specific crystal orientation; and

forming a top electrode on top of said piezoelectric film;

wherein said step of forming a bottom electrode comprises the steps of forming a first layer by an ion beam assist method whereby irradiating ion beams on the bottom electrode, said bottom electrode has a specific crystal orientation, and forming a second layer by continuing deposition with the ion beam assist stopped.

~~15~~ ~~25~~ (Original) The method for manufacturing a piezoelectric device according to claim ~~14~~ ~~27~~, wherein said piezoelectric film is formed on top of said bottom electrode by epitaxial growth.

29. (Withdrawn) A method for manufacturing a piezoelectric device comprising the steps of:

forming an intermediate film that functions as a buffer layer or a diaphragm on a substrate;

forming a bottom electrode on top of said intermediate film;

forming a piezoelectric film on top of said bottom electrode; and

forming a top electrode on top of said piezoelectric film;

AMENDMENT UNDER 37 C.F.R. § 1.312
U.S. Application No. 10/705,251
Attorney Docket No. Q78440

wherein said step of forming an intermediate film comprises the steps of forming a first layer with an in-plane orientation by an ion beam assist method, and forming a second layer by continuing deposition with the ion beam assist stopped.

30. (Withdrawn) The method for manufacturing a piezoelectric device according to claim 29, wherein said bottom electrode and said piezoelectric film are successively formed on top of said intermediate film by epitaxial growth.

31. (Withdrawn) The method for manufacturing a piezoelectric device according to claim 26, 27 or 29, wherein a combination of said step of forming a first layer and said step of forming a second layer is repeated a ~~multiple~~ number of times.

16 ~~32~~. (Previously presented) A method for manufacturing a piezoelectric device comprising the steps of:

forming a bottom electrode on a substrate by an ion beam assist method, wherein by irradiating ion beams on the bottom electrode, said bottom electrode has a specific crystal orientation;

forming a piezoelectric film on top of said bottom electrode by an ion beam assist method, wherein by irradiating ion beams on the piezoelectric film, said piezoelectric film has a specific crystal orientation; and

forming a top electrode on top of said piezoelectric film;

AMENDMENT UNDER 37 C.F.R. § 1.312
U.S. Application No. 10/705,251
Attorney Docket No. Q78440

wherein the surface on which said piezoelectric film is to be formed is irradiated with an ion beam prior to the formation of said piezoelectric film.

17 ~~18~~ (Original) The method for manufacturing a piezoelectric device according to claim 16, wherein said piezoelectric film is formed by epitaxial growth following said ion beam irradiation.

18 ~~19~~ (Previously presented) A method for manufacturing a piezoelectric device comprising the steps of:

forming a bottom electrode on a substrate by an ion beam assist method, wherein by irradiating ion beams on the bottom electrode, said bottom electrode has a specific crystal orientation;

forming a piezoelectric film on top of said bottom electrode by an ion beam assist method, wherein by irradiating ion beams on the piezoelectric film, said piezoelectric film has a specific crystal orientation; and

forming a top electrode on top of said piezoelectric film;

wherein the surface on which said bottom electrode is to be formed is irradiated with an ion beam prior to the formation of said bottom electrode.

AMENDMENT UNDER 37 C.F.R. § 1.312
U.S. Application No. 10/705,251
Attorney Docket No. Q78440

~~19~~ (Original) The method for manufacturing a piezoelectric device according to claim
~~18~~ wherein said bottom electrode and said piezoelectric film are successively formed by
epitaxial growth following said ion beam irradiation.

36. (Withdrawn) A method for manufacturing a piezoelectric device comprising the
steps of:

forming an intermediate film that functions as a buffer layer or a diaphragm on a
substrate;

forming a bottom electrode on top of said intermediate film;

forming a piezoelectric film on top of said bottom electrode; and

forming a top electrode on top of said piezoelectric film;

wherein the surface on which said intermediate film is to be formed is irradiated with an
ion beam prior to the formation of said intermediate film.

37. (Withdrawn) The method for manufacturing a piezoelectric device according to
claim 36, wherein said intermediate film, said bottom electrode and said piezoelectric film are
successively formed by epitaxial growth following said ion beam irradiation.

38. (Withdrawn) A method for manufacturing a liquid jetting head comprising the steps
of:

forming a piezoelectric device by the manufacturing method according to claim 1, 2, 8, 14, 26, 27, 29, 32, 34, or 36; and

forming cavities whose internal volumes are caused to vary according to the deformation of said piezoelectric film of said piezoelectric device in said substrate of said piezoelectric device.

39. (Withdrawn) A method for manufacturing a liquid jetting device which uses a liquid jetting head formed by the manufacturing method according to claim 38.

40. (Canceled).

~~20~~ ~~20~~. (Previously presented) A method for manufacturing a ferroelectric device comprising the steps of:

forming a bottom electrode on a substrate by an ion beam assist method, wherein by irradiating ion beams on the bottom electrode, said bottom electrode has a specific crystal orientation;

forming a ferroelectric film on top of said bottom electrode by performing a process in which a sol containing the material of the ferroelectric film is applied as a coating, dried and degreased to form a precursor, and this precursor is then fired; and

forming a top electrode on top of said ferroelectric film;

AMENDMENT UNDER 37 C.F.R. § 1.312
U.S. Application No. 10/705,251
Attorney Docket No. Q78440

wherein said precursor is irradiated with an ion beam at least once following said degreasing in said step of forming said ferroelectric film.

22 42. (Currently amended) The method for manufacturing a ferroelectric device according to ~~claim 40~~ ²¹ ~~claim 41~~ ²⁰ or claim ~~41~~, wherein said ferroelectric film contains a solid solution of PMN_y-PZT_{1-y} consisting of a relaxer material PMN comprising any of the compounds Pb(M_{1/3}N_{2/3})O₃ (M = Mg, Zn, Co, Ni, Mn; N = Nb, Ta), Pb(M_{1/2}N_{1/2})O₃ (M = Sc, Fe, In, Yb, Ho, Lu; N = Nb, Ta), Pb(M_{1/2}N_{1/2})O₃ (M = Mg, Cd, Mn, Co; N = W, Re) or Pb(M_{2/3}N_{1/3})O₃ (M = Mn, Fe; N = W, Re) or mixed phases of these compounds, and Pb(Zr_xTi_{1-x})O₃ (PZT, 0.0 ≤ x ≤ 1.0), and is oriented in any of the orientations of a cubic crystal (100), tetragonal crystal (001), rhombohedral crystal (100) or quasi-cubic crystal (100).

21 ~~41~~ (Previously presented) A method for manufacturing a ferroelectric device, the method comprising:

forming a bottom electrode on a substrate by an ion beam assist method, wherein by irradiating ion beams on the bottom electrode, said bottom electrode has a specific crystal orientation;

forming a ferroelectric film on top of said bottom electrode by an ion beam assist method, wherein by irradiating ion beams on the ferroelectric film, said ferroelectric film has a specific crystal orientation; and

forming a top electrode on top of said ferroelectric film.

AMENDMENT UNDER 37 C.F.R. § 1.312
U.S. Application No. 10/705,251
Attorney Docket No. Q78440

23

~~23~~ (Original) The method for manufacturing a ferroelectric device according to claim

21

~~23~~, wherein said ferroelectric film contains a solid solution of $\text{PMN}_y\text{-PZT}_{1-y}$ consisting of a relaxer material PMN comprising any of the compounds $\text{Pb}(\text{M}_{1/3}\text{N}_{2/3})\text{O}_3$ ($\text{M} = \text{Mg, Zn, Co, Ni, Mn; N} = \text{Nb, Ta}$), $\text{Pb}(\text{M}_{1/2}\text{N}_{1/2})\text{O}_3$ ($\text{M} = \text{Sc, Fe, In, Yb, Ho, Lu; N} = \text{Nb, Ta}$), $\text{Pb}(\text{M}_{1/2}\text{N}_{1/2})\text{O}_3$ ($\text{M} = \text{Mg, Cd, Mn, Co; N} = \text{W, Re}$) or $\text{Pb}(\text{M}_{2/3}\text{N}_{1/3})\text{O}_3$ ($\text{M} = \text{Mn, Fe; N} = \text{W, Re}$) or mixed phases of these compounds, and $\text{Pb}(\text{Zr}_x\text{Ti}_{1-x})\text{O}_3$ (PZT, $0.0 \leq x \leq 1.0$), and is oriented in any of the orientations of a cubic crystal (100), tetragonal crystal (001), rhombohedral crystal (100) or quasi-cubic crystal (100).

24

~~23~~ (Previously presented) The method for manufacturing a ferroelectric device

21

according to claim ~~23~~, wherein said bottom electrode contains any of the compounds M_2RuO_4

($\text{M} = \text{Ca, Sr, Ba}$), RE_2NiO_4 ($\text{RE} = \text{La, Ce, Pr, Nd, Pm, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Y}$), $\text{REBa}_2\text{Cu}_3\text{O}_y$ ($\text{RE} = \text{La, Ce, Pr, Nd, Pm, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Y}$).

MRuO_3 ($\text{M} = \text{Ca, Sr, Ba}$), $(\text{RE},\text{M})\text{CrO}_3$ ($\text{RE} = \text{La, Ce, Pr, Nd, Pm, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Y}$;

$\text{M} = \text{Ca, Sr, Ba}$), $(\text{RE},\text{M})\text{MnO}_3$ ($\text{RE} = \text{La, Ce, Pr, Nd, Pm, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Y}$;

$\text{M} = \text{Ca, Sr, Ba}$), $(\text{RE},\text{M})\text{CoO}_3$ ($\text{RE} = \text{La, Ce, Pr, Nd, Pm, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Y}$;

$\text{M} = \text{Ca, Sr, Ba}$, or RENiO_3 ($\text{RE} = \text{La, Ce, Pr, Nd, Pm, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Y}$), or a solid solution containing these compounds, and is

oriented in any of the orientations of a cubic crystal (100), tetragonal crystal (001), rhombohedral crystal (100) or quasi-cubic crystal (100).

AMENDMENT UNDER 37 C.F.R. § 1.312
U.S. Application No. 10/705,251
Attorney Docket No. Q78440

Ce_yO_7 ($0.0 \leq y \leq 1.0$; RE = La, Ce, Pr, Nd, Pm, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Y) or a solid solution of such compounds, and has a cubic crystal (100) orientation.

25 (Original) A method for manufacturing a ferroelectric device comprising the steps of:

forming a bottom electrode on a substrate;

forming a ferroelectric film on top of said bottom electrode; and

forming a top electrode on top of said ferroelectric film;

wherein said step of forming a ferroelectric film comprises the steps of forming a first layer with an in-plane orientation by an ion beam assist method, and forming a second layer by continuing deposition with the ion beam assist stopped.

26 (Previously presented) A method for manufacturing a ferroelectric device comprising the steps of:

forming a bottom electrode on a substrate;

forming a ferroelectric film on top of said bottom electrode by an ion beam assist method,

wherein by irradiating ion beams on the ferroelectric film, said ferroelectric film has a specific crystal orientation; and

forming a top electrode on top of said ferroelectric film;

wherein said step of forming a bottom electrode comprises the steps of forming a first layer with an in-plane orientation by an ion beam assist method, whereby irradiating ion beams

AMENDMENT UNDER 37 C.F.R. § 1.312

U.S. Application No. 10/705,251

Attorney Docket No. Q78440

on the bottom electrode, said bottom electrode has a specific crystal orientation and forming a second layer by continuing deposition with the ion beam assist stopped.

54. (Withdrawn) A method for manufacturing a ferroelectric device comprising the steps of:

forming an intermediate film that functions as a buffer layer on a substrate;

forming a bottom electrode on top of said intermediate film;

forming a ferroelectric film on top of said bottom electrode; and

forming a top electrode on top of said ferroelectric film;

wherein said step of forming an intermediate film comprises the steps of forming a first layer with an in-plane orientation by an ion beam assist method, and forming a second layer by continuing deposition with the ion beam assist stopped.

27 (Previously presented) A method for manufacturing a ferroelectric device comprising the steps of:

forming a bottom electrode on a substrate by an ion beam assist method, wherein by irradiating ion beams on the bottom electrode, said bottom electrode has a specific crystal orientation;

forming a ferroelectric film on top of said bottom electrode by an ion beam assist method, wherein by irradiating ion beams on the ferroelectric film, said ferroelectric film has a specific crystal orientation; and

AMENDMENT UNDER 37 C.F.R. § 1.312

U.S. Application No. 10/705,251

Attorney Docket No. Q78440

forming a top electrode on top of said ferroelectric film;

wherein the surface on which said ferroelectric film is to be formed is irradiated with an ion beam prior to the formation of said ferroelectric film.

78 99 (Previously presented) A method for manufacturing a ferroelectric device comprising the steps of:

forming a bottom electrode on a substrate by an ion beam assist method, wherein by irradiating ion beams on the bottom electrode, said bottom electrode has a specific crystal orientation;

forming a ferroelectric film on top of said bottom electrode by an ion beam assist method, wherein by irradiating ion beams on the ferroelectric film, said ferroelectric film has a specific crystal orientation; and

forming a top electrode on top of said ferroelectric film;

wherein the surface on which said bottom electrode is to be formed is irradiated with an ion beam prior to the formation of said bottom electrode.

57. (Withdrawn) A method for manufacturing a ferroelectric device comprising the steps of:

forming an intermediate film that functions as a buffer layer on a substrate;

forming a bottom electrode on top of said intermediate film;

forming a ferroelectric film on top of said bottom electrode; and